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Review of renewable energy use in Lithuania

Dalia Streimikiene [a,*], Juozas Burneikis [a], Petras Punys [b]

[a] *Lithuanian Energy Institute, Breslaujos 3, LT-3035 Kaunas, Lithuania*
[b] *Lithuanian University of Agriculture, Universiteto 10, LT-4324,* Kaunas-Akademija*, Lithuania*

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Abstract

Lithuania has very limited energy resources of its own. The main source of electricity production in Lithuania is Ignalina NPP. Over the last five years, it has generated 80–85% of the total electricity production. The anticipated closure of this nuclear power plant in 2010 will decrease the diversification of fuel supply and there is no huge potential for renewable energy use in Lithuania. Only biofuel, hydro and wind power can be considered as potential renewable energy sources in Lithuania.

The share of renewable energy sources in the Lithuanian primary energy supply is the lowest among the three Baltic states (Estonia, Latvia and Lithuania), though the trends of development are positive. The Lithuanian national energy strategy adopted in 2002 sets the strategic priorities of Lithuanian energy sector development. One of the main strategic priorities is striving to achieve a share of renewable energy sources in primary energy supply of 12% by 2010. The strategy of development of the sector of indigenous renewable and waste energy resources states that in 2000, the share in the overall primary energy balance of indigenous, renewable and waste energy resources (indigenous crude oil excluded) amounted to about 9% in Lithuania. The target is to ensure that approximately 2 million tons of oil equivalent of the above resources are used per year by 2010. The article presents a review of the present renewable energy situation and assessed potential of renewable energy sources in Lithuania. The problem related to the use of renewable energy sources and polices to enhance the use of these sources are analysed in the article.

Keywords: Renewable energy source; Measures to enhance use of renewables

* Corresponding author. Tel.: +370-614-03424; fax: +370-373-51271.
E-mail address: dalia@isag.mail.lei.lt (D. Streimikiene).

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1. Introduction

Renewable energy sources (including biomass, solar, wind, geothermal and hydropower) that use indigenous resources have the potential to provide energy services with zero or almost zero emissions of both air pollutants and greenhouse gases. Currently, renewable energy sources (RES) supply 16% of the total world energy demand. The supply is dominated by traditional biomass used for cooking and heating, especially in rural areas of developing countries.

During the last few years, political support for renewable energies has been growing continuously both at the national and international level. The European Commission approved the implementation of the "Community strategy and action plan on renewable energy", and the European Parliament adopted a directive on the "Promotion of electricity produced from renewable energy sources in the internal electricity market". The World Summit on Sustainable Development held in Johannesburg adopted a joint declaration on "The way forward on renewable energy", which recommended promoting diversified energy supply by developing advanced energy technologies, including fossil fuel and renewables. The Fifth Ministerial Conference on Environment for Europe in 2003 stressed the importance of actions to be taken to substantially increase the global share of RES.

Countries in Western Europe see the increase of the share of renewables as a strategic way of reducing greenhouse gas (GHG) emissions. The EU white paper sets a common average target to increase the share of renewables in total primary energy supply from the current 6% to 12% by 2010 and the share of electricity pro-

duced from renewables from 14% to 22%. These targets practically correspond to the EU commitment on CO_2 emission reduction by 2012.

Transition economies, especially EU accession countries, are positively disposed to the promotion of RES. Many countries view renewables as a way of promoting the development of small and local businesses in selected areas and diversifying supply patterns at the regional level. Some countries have developed national programmes and set national indicative targets for renewables. The first group of accession countries is to comply with the EU Directive on Renewables, which urges EU member states to set national indicative targets for the consumption of electricity produced from renewables which should be consistent with any national commitments made as part of the climate change commitments accepted by the Community under the Kyoto Protocol.

Lithuania has ambitious quantitative targets for renewables. The energy strategy [1] has set up a target for 2010, with RES generating 12% of the energy supply of which electricity produced by RES should amount to 7%. The share of RES in Lithuanian primary energy supply is quite low compared with the other Baltic states (Estonia and Latvia) though the trends are positive. The achievements of a policy promoting the use of RES in Lithuania should be continued in order to maintain the positive trends in the use of RES and to implement quantitative targets for renewables. Reference values for accession countries' national indicative targets for the contribution of electricity produced from renewable energy sources (RES-E) to gross electricity consumption by 2010 are presented in Table 1.

As one can see from Table 1, the Lithuanian indicative target is to double the share of RES in electricity generation in year 2010 from that of 1999. Some countries have much more difficult tasks; for example, Estonia has to increase electricity generation from RES by more than 25 times.

Table 1
National indicative targets for the contribution of electricity produced from RES of Accession countries

	RES-E (TW h), 1999	RES-E (%), 1999	RES-E (%), 2010
Czech Republic	2.36	3.8	8
Estonia	0.02	0.2	5.1
Cyprus	0.002	0.05	6
Latvia	2.76	42.4	49.3
Lithuania	0.33	3.3	7
Hungary	0.22	0.7	3.6
Malta	0	0	5
Poland	2.35	1.6	7.5
Slovenia	3.66	29.9	33.6
Slovakia	5.09	17.9	31
EU-15[a]	338.41	13.9	22
EU-25[b]	355.2	12.9	21

[a] Data refer to 1997.

[b] Data refer to 1997–2000.

2. The main geographical, economic and energy data for Lithuania

Lithuania's geographic location has several advantages for extensive use of most of the RES. Lithuania is a low-lying country and has an area of 65 200 km^2. It lies in Eastern Europe, on the coast of the Baltic Sea. The length of the coastline is 99 km. In the north Lithuania borders with Latvia, in the east and south with Byelorussia, and in the southwest with Poland and with the Kaliningrad region of the Russian Federation. The greater part of the Lithuanian territory is lowlands separated by low hills.

The climate is transitional between maritime and continental. The average annual temperature is about 6 °C. The average temperature in January is −4.8 °C (in Ignalina). The average temperature in July is 17.2 °C, fluctuating from 16.5 °C (in Klaipeda) to 17.6 °C (in Kaunas). The mean annual precipitation varies from 540 mm (in the Middle Lowlands) to 930 mm (on the southwest slopes of the Zemaitija Uplands). The greatest amount falls in August, and on the coast in October. The vegetation season in Lithuania lasts from 169 to 202 days (the shortest is in Eastern Lithuania, the longest in the coastal area). The rivers do not have large flows and may be frozen up to three months a year during the winter.

Historically, Lithuania is an agricultural country. Even nowadays, the agricultural sector performs very important economic, social, environmental and ethnocultural functions. Utilised agricultural area accounts for 53.4% of the total country's total area. Forests, water bodies, roads, built-up territories and other land cover, respectively, 30.6%, 4.0%, 2.0%, 2.9% and 7.1%.

The Lithuanian GDP has risen steadily since 1994 (1999 excluded) by 3.3–7.3%. It increased in 2002 by 6.7% (in 2000—4.0%, in 2001—6.5%), which amounted to about € 13.3 billion at current prices. The main economic and energy data for year 2002 are presented in Table 2.

The dynamics of the total primary energy supply structure is presented in Fig. 1. Primary energy supply amounted to 8.1 Mtoe in 2002. In the structure of primary energy supply, oil products amounted to 33%, natural gas to 30%, solid fuel to 8% and nuclear energy to 28.5%. Hydro energy made up to only 0.4% in 2002.

The structure of the Lithuanian primary energy supply is very favourable with respect to GHG emissions. In the future, when Ignalina NPP will be closed, the share of nuclear energy will be replaced by fossil fuel, but it does not mean that GHG emissions would increase so significantly (almost 3 times) comparing with the current low GHG emission level [2].

The dynamics of final energy consumption is presented in Fig. 2. Final energy consumption in Lithuania amounted to 4.6 Mtoe in 2002.

Final electricity consumption in 2002 amounted to 6722 GW h. The share of nuclear energy in electricity generation in 2002 was 74%, hydro 2.5%, and thermal power plants 20.7%. The structure of final electricity consumption in Lithuania was the following in year 2002: industry consumed 37.4%, transport 1.3%, agriculture 3% and the residential sector 29%.

Overall energy generation from RES and indigenous energy resources in 2002 and the amount of remaining potential are given in Fig. 3. As one can see that

Table 2
The main economic and energy data for Lithuania

	Main data	Unit	2002
1	GDP	Billion €	13.3
2	Population	Thousand inhabitants	3481
3	GDP per capita	Thousand € per capita	3.8
4	Primary energy supply	Mtoe	8.06
5	Final energy consumption	Mtoe	4.6
6	Gross electricity consumption (gross production + import − export)	TW h	10.7
7	Final electricity consumption	TW h	6.4
8	Primary energy per capita	toe per capita	2.3
9	Final energy per capita	toe per capita	1.3
10	Electricity production per capita	kW h per capita	4234
11	Gross electricity consumption per capita	kW h per capita	2878
12	Final electricity consumption per capita	kW h per capita	1852
13	Primary energy per GDP unit	kgoe/thousand €	60
14	Final energy per GDP unit	kgoe/thousand €	34
15	Gross electricity consumption per GDP unit	kW h/thousand €	80
16	Final electricity consumption per GDP unit	kW h/thousand €	48
17	Degree of self-sufficiency (net import)	%	53

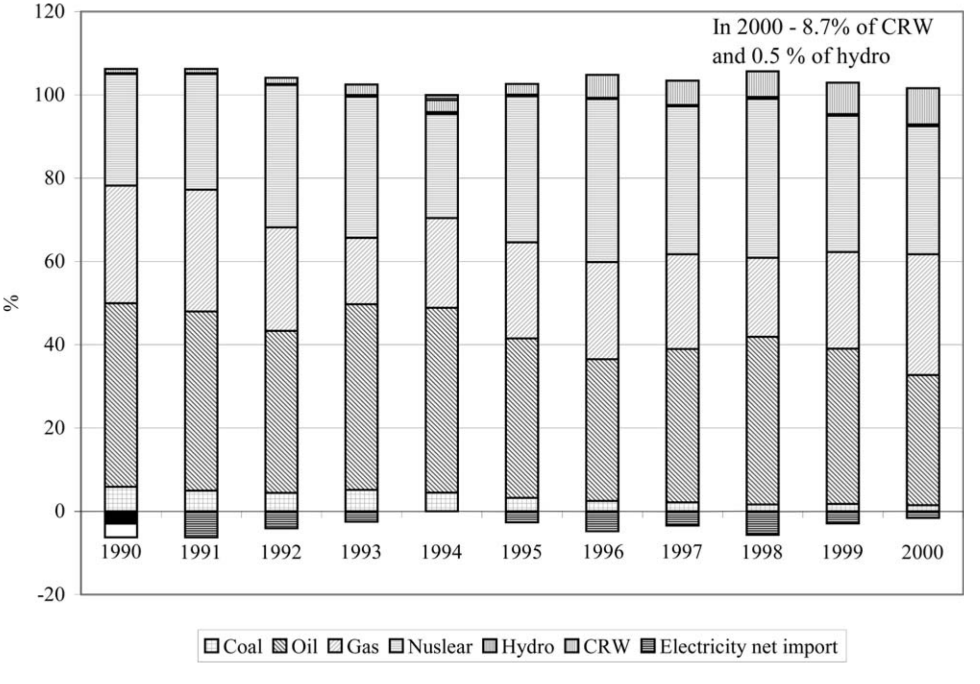


Fig. 1. Total primary energy supply distribution by fuel type.

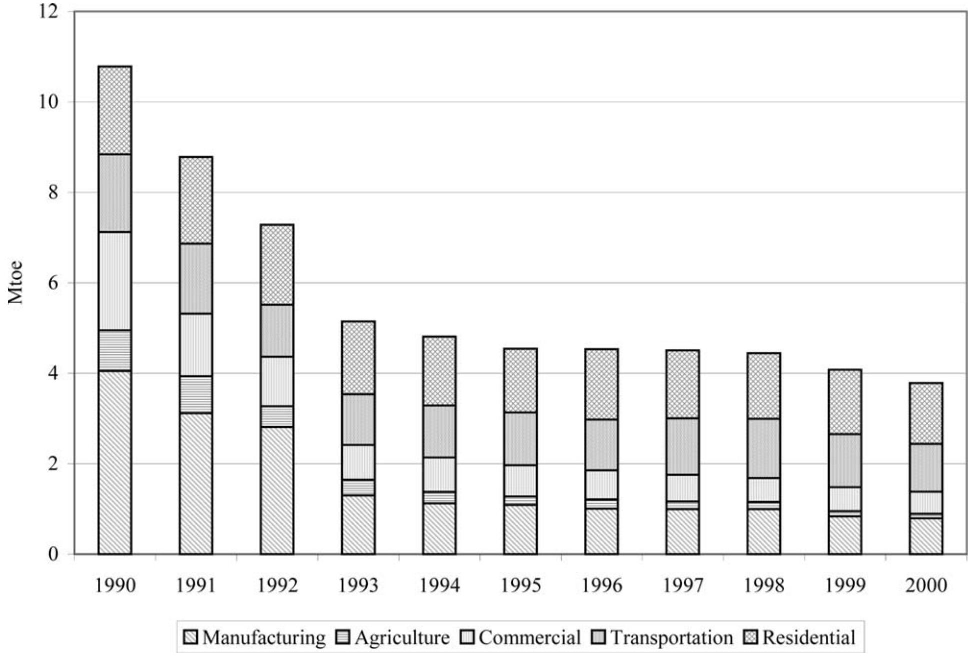


Fig. 2. Final energy consumption by economic sector.

firewood and wood waste are the most commonly used RES in Lithuania. The remaining RES, in comparison with the former, are undeveloped as yet, except hydropower resources and peat.

After the closure of Ignalina NPP in 2010, the structure of primary energy supply as well as fuel consumption for electricity production will change significantly in Lithuania. There are no possibilities in Lithuania to replace nuclear by hydropower, but there is a lot of space in Lithuanian for the development of local and renewable energy resources [3].

The enhancement of the use of RES in Lithuania is a very important issue because of the security of supply and environmental requirements.

According to EC COM (2000) 769 (green paper “Towards a European strategy for security of energy supply”), the EU long-term strategy for energy supply security must be geared to ensure the well-being of its citizens, proper functioning of the economy, and uninterrupted physical availability of energy products on the market, at a price which is affordable for all consumers while respecting environmental concerns. Security of supply does not seek to maximise energy self-sufficiency or to minimise dependence but aims to reduce risks related to such dependence. Among the objectives to be pursued are those balancing between and diversifying the various sources of supply (by product and by geographical region). Preparing the energy sector development strategy for Lithuania’s security of supply should be

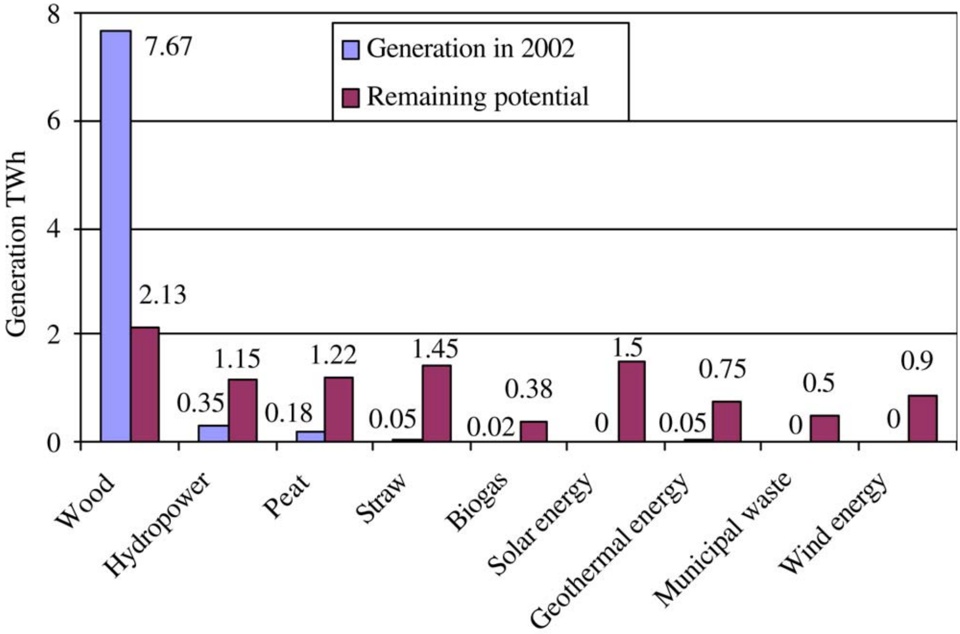


Fig. 3. Energy generation from RES and indigenous energy resources in 2002.

considered a very important issue and possibilities to increase the diversification of fuels by increasing the share of local and RES should be taken into account.

3. Environmental requirements for the energy sector

3.1. Overall policy related to energy

The main environmental problem related to energy production and consumption is atmospheric pollution. Due to economic recession and decrease in energy demand, atmospheric pollution from stationary pollution sources in Lithuania has declined more than 4 times compared with the 1990 level. In 2000, stationary pollution sources emitted 91 200 tons of pollutants into the atmosphere (in 1990—385 400 tons).

The main source of atmospheric pollution is fuel combustion. Seeking to implement the requirements of international commitments, the Ministry of Environment regularly provides information to United Nations and EU institutions regarding the amount of pollutants emitted into the atmosphere, which are being inventoried according to the fuel and energy balance maintained by the Department of Statistics. The following main pollutants are being assessed: SO_2, CO, NO_x, volatile organic compounds (VOC), CH_4 and particulates. They make

up 90–98% of all pollutants emitted into the atmosphere. CO_2, which is emitted into the atmosphere in huge quantities, approximately 15 times higher than other pollutants, is not treated as harmful (like all other greenhouse gases), but assessment and control of these emissions are necessary because they have an impact on climate change. Emissions into the atmosphere from energy producing enterprises make up more than 40% of all stationary pollution emissions and only about 10% of all emissions [4].

Up to now, Lithuania meets all the requirements of signed international conventions in the field of atmospheric pollution. The United Nations Convention on Long-Range Transboundary Air Pollution was ratified on 27 October 1993 by the Order of the Government of the Republic of Lithuania No. 737. The countries that have signed the convention agreed on air pollution (SO_2, NO_x, VOC) control and defined pollution reduction targets or possibilities to maintain the current pollution level. The protocols of these conventions foresee concrete pollution reduction targets for different pollutants. The Helsinki Protocol (1985) requires reducing emissions of sulphur or its compounds by at least 30% from the 1980 level. The Gothenburg Protocol (1999) sets SO_2, NO_x, NH_3 and VOC reduction targets for participating countries up to year 2010 compared with the pollution level in year 1990. Though Lithuania has not signed these protocols, it is ready to do this soon. The Lithuanian national pollution limits according to the Gothenburg Protocol for year 2010 are: to reduce the SO_2 emission level by 35%, NO_x by 30%, NH_3 by 0% and VOC by 15% compared with the 1990 level [5].

One hundred and fifty five countries have signed the United Nations Framework Convention on Climate Change (UNFCCC) in Rio de Janeiro on June 1992. The Lithuanian Parliament has ratified the UNFCCC on 23 February 1995 and it has come into force since 22 June 1995. Lithuania committed itself to reduce GHG emissions, which are not being controlled under the Montreal Protocol on Substances that Deplete the Ozone Layer to the 1990 level by year 2010.

Countries which signed the UNFCCC in 1997 agreed on the Kyoto Protocol. Lithuania has signed this protocol in 1998 and committed itself to reduce emissions of GHG by 8% from the 1990 level by 2008–2012 (GHG emissions may not exceed 39 million tons in 2008–2012). The Kyoto Protocol is still not ratified. For the ratification of this protocol, it is necessary that at least 55% of the participating countries or countries responsible for more than 55% of the GHG emission in 1990 should ratify it. The Lithuanian Parliament ratified the Kyoto Protocol on 20 November 2002. It is important to mention that in 1990, GHG emissions in Lithuania amounted to 42 Mt and today they amount to about 17 Mt.

Comparing with other countries, Lithuania's contribution to global climate change is very small. Large amounts of GHG are being emitted from such countries as Japan and Germany. In USA, emissions of GHG come to 5.6 billion tons in CO_2 equivalent annually, in China 3.1 billion tons, and in Russian Federation 1.5 billion tons. GHG emissions in Lithuania come to about 4.8 tons/person. The Lithuanian GHG emissions are compatible with the emissions of most European countries, which emit from 3 to 7 tons of CO_2 equivalent per person.

The main EU environmental requirements for the energy sector are defined by the following directives: EC Directive 2001/80/EC on the limitation of emissions of certain pollutants into the air from large combustion plants (LCPs) and Directive 1999/32/EC on reduction of the sulphur content of heavy fuel oil (HFO) to 1%.

The sulphur directive 1999/32/EC has been transposed into Decree No. 438/268/266 of the Ministers of Environment, Economics and Transport and Communications, which prohibits the use of HFO with a sulphur content greater than 1% by mass within the territory of Lithuania from 1 January 2004 unless the emissions of SO_2 are kept below 1700 mg/N m^3.

The emission limit values for pollutants from large combustion plants and implementing procedures of Directive 2001/80/EC are defined in Lithuania by the Decree of the Minister of Environment No. 486. According to the decree, all large combustion plants with thermal input higher than 50 MW are required, by 1 January 2008 at the latest, to comply with the stringent requirements for SO_2, NO_x, and particulates emissions.

According to the requirements of EU Directive 88/609/EEC, it is possible to burn HFO with a sulphur content exceeding 1% if it is co-combusted with either natural gas or biomass. Thus, HFO—having a sulphur content of 2.2%—can be used by large combustion plants if it is co-combusted with at least 55% natural gas or 55% biomass (in terms of energy input). In this case, the concentration of SO_2 in the flue gas will be kept below 1700 mg/N m^3. Similarly, Orimulsion should be co-combusted with at least 75% natural gas [6].

According to the requirements of Directive 2001/80/EC, from 1 January 2008, for the largest Lithuanian power plants, 7 times higher standards for SO_2 emissions should be applied for combusting HFO. During negotiations with EU, Lithuania succeeded in receiving a transitional period for Vilnius, Kaunas and Mazeikiai CHP up to year 2015 for the implementation of these requirements in order to have more time to prepare for these new requirements [5].

According to the forecast of the development of Lithuanian economy, the industry will recover and energy demand will increase. After the shutdown of both units of Ignalina NPP by 2010, electricity will be produced mainly in thermal power plants and atmospheric pollution will increase. But even in the case of very fast economic growth, by 2010 energy demand will be about 10–15% lower than it was in year 1990. Therefore, Lithuania will be able, in the future, to meet all requirements of signed international conventions in the air pollution field, but seeking to ensure this, it is necessary to increase the utilisation of RES and to increase energy efficiency as well as to prepare for the application of all possible strategic climate change mitigation measures such as flexible mechanisms under the Kyoto Protocol (emission trading and joint implementation) [7].

3.2. Environmental requirements for RES development

There is a need to reveal some environmental issues resulting from the development of RES electricity in Lithuania. It is commonly recognised that utilisation of

RES contributes to environmental protection; they are clean means of electricity production. Regardless of these known statements, wind energy, and especially hydropower developments, face a number of improper restrictions resulting from environment protection.

On the one hand, wind energy is still undeveloped in Lithuania; its development is gaining pace but apart from a rough account cannot be precisely described. On the other hand, the ambitious plans to commission 157 MW total capacity of wind farms by 2010 raise some opposition from the specialists of environment protection. Their main accusations are commonly known: change of landscape, obstacle for migrating birds, noise. The spatial plan initiated recently by the Ministry of Economy and submitted to all stakeholders for approval is likely to resolve the technical and environmental issues by giving the green light for wind energy promotion.

Due to the lowland character of the country, the gentle gradient of the streams results in relatively small height of the hydropower plants (HPPs) dams usually not exceeding 3–5 m. Consequently, the capacity of the power plants is rather moderate—from a few hundred kilowatts up to several megawatts, and they all can be considered as small (except one large—Kaunas HPP).

Lithuania like most industrialised countries, has a generalised environmental impact assessment (EIA) legislation aimed at all types of development projects. The term EIA, following the definition in EU Directive 85/337/EEC of 27 June 1985, applies to the identification, description, and assessment of direct and indirect effects of a project on: human beings, fauna and flora; soil, water, air, climate and landscape; the interaction of these factors; and material assets, and the cultural heritage.

According to the former law on EIA (1996), two categories of EIA were foreseen: initial and full EIAs. Taking into account EU Directive 97/11/EC of 3 March 1997 and other requirements relative to environmental impact studies, this law has been amended (2000). This legal act entitled "Law on Environmental Impact Assessment of the Proposed Economic Activity" now takes into consideration all elements and aspects usually included in EIAs: from project preparation, screening and scoping to decision by the competent authority. A specific legal act published by the Ministry of Environment (MoE) (2000) provides well-determined rules for public involvement in the EIA process.

Depending on a particular project's, there are two options: mandatory requirement or screening. Typical guidance is available to perform the screening process. Of all RES, only wind energy and hydropower projects are subject to EIA. However, they are not directly included in the mandatory list for EIA. If the height of a wind farm (including wingspan) exceeds 10 m, screening of this project must be performed. A hydropower plant of capacity greater than 100 kW is also subject to screening. This requirement should be considered a strong one, as the dam height is 2–3 m.

The order of the Ministry of Environment (1996) dealing with environmental issues distinguishes between hydropower schemes with installed power up to 10 MW (small abstractions) and schemes with an installed power over 10 MW (large abstractions). This definition regarding hydropower plant scale has been set in accordance with the European Small Hydropower Association (ESHA) recommendations. However, taking into account the country's topographical con-

ditions (only low head hydropower plants can be developed here), this threshold capacity should be much lower: 1–2 MW.

In the last few years, the hydropower situation, particularly that of small plants, regarding environmental restrictions, comparing them with wind energy projects, has been considerably aggravated.

A well-structured system of protected areas was introduced in Lithuania before World War II. Protected areas currently occupy from 11.5% of the whole territory. Within these territories, protected rivers and their reaches have been excluded from damming and other kinds of economic activity. The Ministry of Environment has passed the order establishing the list of watercourses and their reaches exempted from any dam construction [8,9]. A total of 147 watercourses are listed. Almost 90% of all watercourses attractive for small hydro development are covered by this list. Apart from the various kinds of protected in existence areas (ichthyological, hydrographical, landscape, national parks and others) that were established a long time ago, new rivers and their reaches appeared in this list.

This list, which does not take into account the height of the dam, intends to protect valuable fish species and promote fisheries in the rivers. There is no question even about mitigation measures (e.g. construction of fish passages etc.). The impact of this order is crucial: the economically and environmentally justifiable small-scale hydropower potential has been diminished from the previous 14% to currently about 6%. Comparing this figure in relative terms with similar small-scale hydropower sector in the EU (average of 25–30%), one can state that it is the lowest. This proves that the environmental restrictions in Lithuania are too severe for small-scale hydropower development [10].

In contrast, for instance, Sweden introduced (May 2003) a green certificate system to support electricity from RES (RES-E) in response to the targets set in Directive 2001/77/EC. All RES-E production plants will receive certificates in relation to their production except hydropower plants with capacity exceeding 1.5 MW. The certificate system is supposed to give producers a support of about € 15/MW h [11].

When establishing the list of forbidden rivers in Lithuania, only the EU directives and conventions dealing with fauna and flora protection such as Habitats (Council Directive 92/43/EEC on the conservation of natural habitats and wild fauna and flora), Bern (Council of Europe, 19.IX.1979, convention on the conservation of natural habitats and wild fauna and flora), HELCOM (Helsinki convention on the protection of the marine environment of the Baltic Sea area, 1992), and Natura 2000 (network of protected areas in the EU, 2000) were taken into account. In the other words, their requirements were transposed even stricter than the original texts to national environmental legislation. The authorities of environmental protection completely ignored the EU Directive on RES-E. Following them neither small nor large hydro power sources can be regarded as sustainable energy sources producing green electricity. Even worse—small hydropower stations disturb river basin management and threaten protected species and important habitats.

If we look more deeply into this issue, a collision between the EU legal systems, on the one hand, of environment (water) protection and on the other hand, of

RES-E development, particularly hydropower can be observed. The goals of both legal frameworks are the same—to protect the environment of the river ecosystems and reduce GHG emissions and other emissions into the atmosphere.

The conclusion can be made that Lithuania's environmental requirements regarding small-scale hydro power (dam height generally varies from 3 to 5 m) are too strict and unjustifiable from either point of view.

4. Renewable energy use in Lithuania

Studies of indigenous energy resources performed in Lithuania during recent years show that the statement of the European Union, to cover approximately 12% of the internal energy demand of each country through renewable energy resources, could be implemented in principle. Pilot projects implemented in recent years justify the possibility to accelerate the use of indigenous energy resources, particularly for heat supply. In 1996, 296 000 toe of indigenous and renewable energy resources (3.1% of internal primary energy consumption) were consumed [12]. The installed capacity for the incineration of wood waste at present reaches approximately 90 MW. The first boilers for incineration of straw are already installed.

Lithuanian authorities are currently breaking down the contribution of each sector to the global indicative target for the share of renewables in the total primary energy supply of 12%. Fig. 4 shows the forecasted amounts of electricity at the end of 2009: total electricity consumption (12 630 GW h), total electricity generated from RES (921 GW h) and production of most promising sectors.

The biggest share of electricity will be provided by large-scale hydropower, the contribution of which will remain stable. An EIA of the 70 MW hydropower plant (expected output of energy—about 228 GW h) on the country's largest river

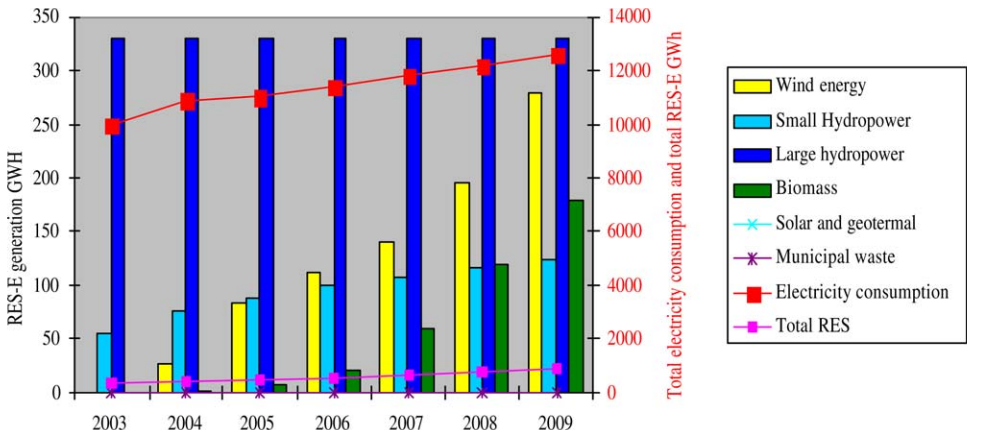


Fig. 4. Lithuanian RES-E indicative targets allocated to individual sectors: breakdown of the contribution of each sector.

Nemunas, has actually been carried out. Its commissioning is likely to take place after 2010. The second largest contributor is planned to be wind energy (from 0 in 2003 to 278 GW h in 2009). Despite the still underused remaining small-scale hydropower potential of watercourses, its share should be considered relatively low here. The strict watercourse protection rules in force in Lithuanian do not allow use of this reliable source of energy. The electricity produced from biomass is planned to increase considerably since 2005. The total contribution of solar, geothermal and municipal waste for electricity production is unlikely to exceed 10 GW h per year by the end of 2009.

However, the current use of RES is rather low in Lithuania. Based on a current report produced by the Danish energy Authority [13], the total number of RE projects implemented in Lithuania is 135. The total capacity of implemented RES projects equals 343.5 MW. The main part of the projects is related to heating. The share of biomass-based RES projects equals 82%. In Lithuania, green electricity is produced mainly from hydro energy. CHP units using biomass and biogas present a limited capacity for electricity production. Wind energy is a potential source for power production. Wood fuel is used in reconstructed (49 units) and new (18 units) boilers. No serious obstacles can be seen for the extension of wood fuel usage.

The increase of indigenous fuel use is restricted by the fast growing and unregulated costs of domestic fuel (sod peat, wood chips) production, which have already reached or even exceeded the price of imported HFO. Without a developed infrastructure of indigenous fuel production and use, its production costs are high. Market relations were not formed in local fuel production sphere. The non-favourable tax policy (royalty tax, VAT, pollution charges, etc.) has had influence on the growth of indigenous fuel prices. So the programme of actions for implementation of the strategy must foresee the solution of these problems. Based on the national energy strategy [1], the use of small HPPs will be developed in two stages:

1. By restoring abandoned and installing new small HPPs at existing water ponds. The actual potential is over 100 small HPPs with a total capacity of 16 MW and annual electricity production of approximately 70 GW h/year.
2. By constructing new dams and small HPPs in favourable sections of medium-sized and small rivers. The technical potential of such power plants does not exceed 500 GW h/year.

Measures provided by the Lithuanian Energy Efficiency Program [12] stimulate much faster use of indigenous and RES. It is forecasted that till 2020, the use of these resources will exceed the current level by 2.8 times approximately (Table 3).

In the following sections, the potential for separate renewable energy resource use in Lithuania will be reviewed.

4.1. Hydro energy potential in Lithuania

The main source of renewable electricity generation in Lithuania is hydropower. Regardless of the huge plans to develop wind energy hydropower will continue to

Table 3
Forecast of consumption of indigenous, renewable and waste energy resources

Resource	Consumption, ktoe	
	2000	2020
Wood waste and firewood	300	500
Municipal waste	132	220
Peat	40	120
Straw	2.6	134
Biogas	2.4	12
Solid household and industrial waste	–	100
Wind energy	0.52	6.3
Solar energy	1.0	300
Geothermal energy	1.8	18
Small hydropower plants	1.7	6.5
Total	498	1417

remain the biggest electricity generator until 2010 (Fig. 4). The technical hydro energy resource potential is about 0.00972×10^9 GJ/year [14]. About 0.00792 GJ/year or 80% of all resources fall to the share of the two largest rivers: Nemunas and Neris [15]. The share of all 470 medium-sized and small rivers is about 0.0018 GJ/year or 20%. Though large HPPs are more attractive than small hydropower plants from an economics point of view, due to surplus power generating capacities, strict environmental requirements, and high investments, they can be considered only in the future when Ignalina NPP will be closed [16]. However, the country's private investors are not waiting for its closure; they have already started investigating the opportunities for harnessing the middle of the largest river, Nemunas. An EIA study is currently being carried out for prospective installation of the 70 MW (exact capacity is not settled yet) plant. There will not be the potential resettlement of communities (only a few people are concerned), but the site for probable impoundment can be characterised as very sensitive (national park, exceptional landscape). It has to be noted that the upper reach of the country's largest river, Nemunas (above Kaunas HPP reservoir), was not excluded from hydropower development by the ministerial order (No. 27/3 D-13 of 16 January 2003).

Small (with capacity less than 10 MW) HPPs built primarily on existing water ponds constructed for irrigation purposes mainly using standard designs and energy facilities and supplying energy to the power grids are economically feasible and profitable. Generally, the Lithuanian landscape is not favourable for hydro energy production. High dams are not available in most cases. Even comparatively low dams cause flooding of large areas. As a potential for hydro energy, already existing dams, earlier used for irrigation purposes, may be considered to be the most realistic opportunity. As a rule, municipalities own these dams, while water basins are used for fishery in some cases. There is a lack of adequate legislation allowing municipalities to rentout for an appropriate fee, or to give license for the use of these dams and hydro technical equipment for energy production.

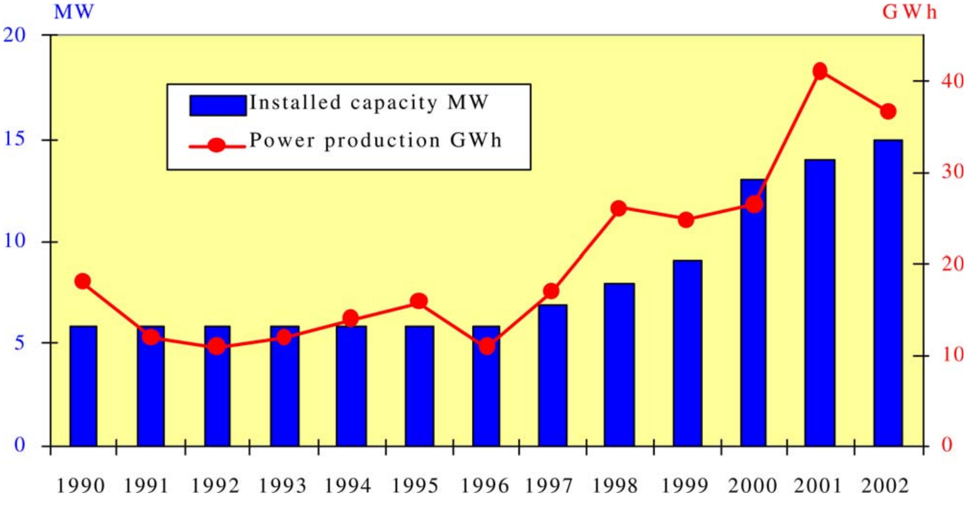


Fig. 5. Small-scale hydropower installed capacity (MW) and electricity generation (GW h).

At present, there are about 50 small HPPs operating in Lithuania. The total capacity of all of them is 15 MW and they produce about 40 GW h electricity per year (Fig. 5).

In Lithuania, micro-hydropower plants include about 88% of all power plants, and small and mini-hydropower plants only 12%. Power plants with an installed capacity of 200–500 kW from the main part (43.1%) of all installed capacity and (38.7%) of all energy production. Distributions of installed capacity, energy production and the percentage of all SHPP according to districts of Lithuania are presented in Table 4.

4.2. Biomass

Biomass and fuelwood are the most popular indigenous energy sources in district heat supply. The increase of wood waste utilisation in district heat supply was stipulated by introduced environmental requirements to the energy sector [5] which urged the conversion of HFO fired boilers into wood fired boilers. District heating systems exist in all major towns and in many smaller towns. The use of local fuel was started in the district heating systems of the smaller towns Birzai, Moletai and Varena. The construction of high capacity plants in major cities causes fuel handling (traffic, noise, storage) problems. The results of analysis show that biomass usage is considered to be cost-effective compared with the usage of HFO or gas, but the availability of the biomass (wood chips) and the location of the biomass sources is an important factor affecting transport prices [17]. The environmental benefit of the usage of biomass is significant. The large reduction concerning the pollutant SO_2 is the result of replacing HFO with 3% sulphur contents, the reduction of the emissions of CO_2 and NO_x are approximately 10–12%.

Table 4
Distribution of installed small HPP capacity in Lithuania

District	Number of SHPP	Installed capacity, kW	Energy production, GJ/year	Energy production, %
Alytus	5	1157	17 300	8.6
Kaunas	6	2780	37 440	18.7
Klaipeda	1	156	2300	1.1
Marijampole	4	1043	8245	4.1
Panevezys	2	50	480	0.2
Siauliai	5	1440	20 610	10.3
Telsiai	10	3510	41 768	20.8
Utena	5	3775	54 540	27.2
Vilnius	9	1250	17 770	8.9
Total	47	15 161	200 453	100.0

The price of wood chips is not regulated in Lithuania and is fixed by contract between consumers and suppliers. The average price of wood fuel in Lithuania is about € 10/J m^3 of solid wood; the fuel price in terms of energy would be € 1.3/GJ [13].

4.3. Straw

Straw started to be used in Lithuania as fuel in district heating boilers only in December 1996 after commissioning of the first straw-burning boiler at Narteikiai Agricultural School. Next year, four straw-burning boilers were installed in different places of Pasvalys region. From the beginning, straw-burning boilers were installed with the technical and financial support of foreign partners. Recently, there are some local companies producing straw-burning boilers (AB "Umega", UAB "Slengiai"). The capacity range of these boilers varies from 15 to 450 kW. Lower capacity boilers are intended for the space heating of individual farmhouses. Large capacity boilers are used for the district heating of settlements and large objects like schools or hospitals located in the countryside [13].

Today, straw fuel is used in nine district heating boilers in five settlements and villages. Eight boilers are batch-fired with periodical feeding of straw (round bales). Only one boiler, in Narteikiai Agricultural School has a straw cutter and an automatic feeding device. A straw fuel market does not exist in the country. The price of straw fuel varies from 1.1 to 1.56 €/GJ depending the method of acquisition [13].

4.4. Wind energy

The climatic conditions in Lithuania are not favourable for wind energy utilisation. Only on the seashore is the wind velocity high enough to build windmills. Constraints in windmill development may occur during the public consideration process in seashore areas, which are used as resorts. Noise may be a problem in

areas situated close to residential districts. The best wind energy potential is in the western and north-western parts of Lithuania, especially on the seashore. Until recently, very little attention was paid to wind energy in Lithuania. Wind energy can be feasible where the average wind velocity is higher than 5–6 m/s. In Lithuania, these are the Baltic shore and Kursiu Nerija. The Western European experience shows that the power price for wind power plants, when the wind velocity is 5–6 m/s, is about 25 ¢.

4.5. Solar energy

The annual solar energy potential in Lithuania is evaluated to be 900–1000 kW h/m^2. This potential can be compared with the solar radiation at similar latitudes in northern Germany and Denmark. It is assumed that solar energy will be used in collectors for preparing hot water, and for heating in passive heating systems of buildings. Solar energy can be used mostly on the seashore, where there number of sunny days is the largest [13].

5. Promotion of renewable energy sources in Lithuania

There are only a few direct support measures or tax incentives for the use of RES in Lithuania. Both of them apply to biofuels. A reduced VAT of 9% was applicable for denaturated dehydrated ethyl alcohol and methyl and ethyl ester produced from rapeseed up to 31 December 2002. Since 1 January 2003 on, denaturated dehydrated ethyl alcohol and methyl and ethyl ester are exempted from VAT. Legal and natural persons using biofuels and who present documents proving the use of biofuels are exempt from the tax for pollution from mobile sources, which is based on fuel consumption and is levied per ton of fuel consumed.

The provisions on green electricity from the Decision of National Control Commission for Prices and Energy Concerning Prices for Public Service Obligations in Electricity Sector (11 February 2002) set the average purchase prices for electricity produced from renewable and waste energy sources:

- € 5.8 ct/kW h for HPPs;
- € 6.4 ct/kW h for wind power plants;
- € 5.8 ct/kW h for power plants using biomass.

Lithuania has no provisions for a system of certificates of origin, as required by Article 5 of the Renewables Directive on Electricity. It needs to develop a mechanism based on the experiences of other EU and candidate countries and to tailor it to the Lithuanian situation.

At present, national rules imposing purchase obligations favouring electricity producers using RES are within an area of community law where wide discretion is available to the member states.

The Lithuanian rules on licensing and authorisation procedures do not appear to have special provisions to streamline or expedite procedures for applications for

authorisation for electricity or heat generation using RES. The Ministry of Economy should consider some of the measures used in other countries, some of which have been identified above. In addition, the Ministry of Economy should ensure that Lithuania undertakes the required evaluation under Article 6 of the RES-E Directive on a timely basis.

The Lithuanian Electricity Act and a couple of Lithuanian regulations establish some prioritisation rights for electricity generated from local, renewable and waste energy resources in a manner that appears to be roughly consistent with the option listed in the existing EC Electricity Directive and with the obligation set forth in Article 7(1) of the RES-E Directive [17].

There are several types of capital support for RES utilisation available in Lithuania: investment subsidies, soft loans, interest subsidies and loan guarantees. The intermediate financing type between support and credits is risk capital. The direct support available for RES utilisation is state aid investment support for any undertaking authorised to pursue the economic activity and National Energy Efficiency program [12] providing finance for demonstrational projects. Soft loans, interest subsidies, loan guarantees and risk capital are available for any RES-related small and medium size business from the special closed stock company based on state capital and small and medium size business support programs governed by municipalities or county chief administrations environment investment fund loan provision for renewable energy activity (as environmental improvement activity) is used for any undertaking authorised to pursue the economic activity. The rural Credit Guarantee Fund provides loan guarantee for banks extending loans for alternatives to agriculture activity—alternative (renewable) energy activity. This kind of support is mainly designed for agricultural enterprises [18].

The dominant type of support in Lithuania is indirect support. The reason is that once the RES are used for energy production, it cannot be directly supported by the state because it distorts the markets and impinges on free competition [19]. Lithuania is obligated to obey the respective provisions of the EU Treaty and bilateral or international agreements on free trade. Without limitations, direct support may be provided to demonstration and pilot projects in the RES field. The conclusion can be drawn that the private sector and municipalities currently underuse the indirect support possibilities for RES-related projects. In order to increase support for RES-related projects, the simplification of EU fund utilisation procedures and requirements on one hand and the improvement of Lithuania's ability to absorb the EU funds on the other hand are needed.

The Lithuanian Energy Institute applied the mathematical model MESSAGE for the energy sector for analysis of the effects of the promotion schemes of renewable energy resources in Lithuania [20]. The lowest electricity and heat price increase is obtained in the case when only institutional measures are applied. In the case of increased emission taxes (SO_2 and NO_x), besides increased price of electricity and heat and visible shift to natural gas in primary energy balance, a big impact on refineries that significantly reduces oil refining and export of oil products can be noticed. Tax on CO_2 causes smaller changes in the Lithuanian energy sector in comparison with increased taxation of SO_2 and NO_x, however, it leads to the high-

est electricity and heat price increase. It has no significant impact on the utilisation of renewable energy resources because of their low availability but leads to further shift from oil to natural gas and import of electricity and consequently to a more negative trade balance [20]. Looking from the point of security of energy supply in Lithuania, this measure might be considered negative because it favours the domination of natural gas in primary energy balance. Nevertheless, this measure reduces CO_2 and SO_2 and provides significant supplementary income to the state budget.

The introduction of excise tax on Orimulsion reduces CO_2 by about 6% and SO_2 by about 4%, and leads to significant additional income to the state budget but, at the same time, causes one of the highest levels of electricity and heat price. The results of analysis indicated that emission taxation schemes, especially increased SO_2 and NO_x taxes, seem to be the least economically attractive or even negative options of all promotion schemes analysed [20].

6. Conclusions

Electricity in Lithuania could be produced by hydro and wind power, as well as combined heat and power (CHP). Regarding small-scale hydropower, it is only possible to augment the production slightly. The electricity produced by wind should amount for the rest. The RES producing heat would be: wood, straw, peat, and geothermal. Heat and electricity could be jointly produced in CHP plants using biogas, wood and straw.

The main obstacle for the enhanced use of RES is the low price of electricity produced from nuclear energy. In many Western European countries, the use of renewable energy resources has been promoted via grassroots organisations. It seems that in Lithuania some obstacles for enhancement of the utilisation of renewable energy resources are created by the fact that there are only a few NGO with the primary focus of developing the use of RES. The Lithuanian Hydropower Association, which maintains close relations with ESHA, has been acting in the national RES market for the promotion of small-scale hydropower since 1994. In order to foster wind energy, recently, in 2003, the Lithuanian Wind Power Association has been established.

Public awareness on the benefits of RES seems to be very low in Lithuania, maybe because the environmental aspect until now, with nuclear energy, has been less predominant. The prices of energy for end users have traditionally been low in Lithuania, but have risen steadily over the last decade. People may fear that increasing use of renewables would create new price rises.

The Kyoto Protocol cannot be seen as a driving force for the enhancement of the use of RES in Lithuania, because the current CO_2 emission levels are lower than the levels in 1990. After the closure of Ignalina NPP in 2010, CO_2 will increase significantly; however, the obligations set by the membership of the EU, and the requirements of the RE directive for a certain part of RE in energy production, could help fulfil the Kyoto Protocol requirements as well.

Though, according to simulation results, increased SO_2 and NO_x taxes seem to be the least economically attractive or even negative options of all promotion schemes analysed, enhancement of the use of RES can be supported in Lithuania by implementing new environmental taxes (for example, CO_2 or product taxes on fuels based on the carbon content of the fuel). A green budget reform analysis is necessary to evaluate the impact of pollution tax increase in Lithuania. Before increasing pollution taxes or introducing a new one, the re-designing of the tax system is necessary. This can be achieved through the reduction of taxes on income, VAT and others and increases in existing environment-related taxes and/or the introduction of new ones to internalise the external costs of energy production and use. The new environmental taxes combined with a reduction in other taxes, preferably distortional taxes (e.g. taxes on personal and corporate income), can yield additional non-environmental benefits, such as greater economic efficiency and development.

Lithuania has direct price support for electricity generated from RES. The average purchase prices for electricity produced from renewable and waste energy sources is set by the National Control Commission for Prices and Energy. New support schemes can be introduced in Lithuania based on the experience of other countries. Flexible market-based support for electricity produced from RES can be given by renewable certificates or green certificates. Currently, Sweden is among the very few countries having already adopted the electricity certificates system. In a few years, a large market for trade in green certificates will have developed and converged into a well-functioning tool. Lithuania can also adopt a system with the features which have proven to be most efficient. This system will ensure that electricity production from RES will not be dependent on financial support from the state, but will be responsive to the deregulated market.

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